Amateur Satellite Communications for Emergency Services

West Central Florida Technical Convention
Polk County Florida 22FEB2020

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ARRL Official Emergency Station, Technical Specialist and AMSAT Ambassador

Special Thanks to the AMSAT Ambassador Network for many excerpts from the AMSAT Academy.

Who am I?

- ARRL Official Emergency Station, AMSAT Ambassador
  - First licensed in 1974 (WN9OEP) in Peoria, IL
  - Extra Class licensee in 1977 (WB9OEP) attending the University of Illinois
- 35 years as an Electrical Engineer for Motorola and Raytheon
- Amateur radio experience includes
  - HF and VHF Contesting
  - Amateur Satellite DX
  - AFMARS, Auxcomm, ARES & Raytheon BCP Auxiliary Communications
  - Long-time AMSAT Area Coordinator (now called AMSAT Ambassadors.)
- Interests today are
  - All-mode DXing
  - Homebrew Stealth Antenna designs
  - Tutoring & Mentoring
  - Emcomms & applications of the Amateur Radio Service, Radio Amateur Civil Emergency Service and the Amateur Satellite Service within the Incident Command Structure.

Agenda

- Introduction to the Amateur Satellite Service
- What, How Why, When & Where of SatComms
- Working the FM “EasySats”
- APRS & Satellite Digipeaters
- Satellite Digipeaters for Safe & Well Messaging

Intro to Amateur Satellites

- OSCAR 1 was launched in 1961
- ITU Convenes WARC-71 in June 1971
  - Amateur Satellite Service created
  - 29 bands are allocated internationally
- Today, we have more than 30 functioning satellites:
  - FM Repeater Satellites
  - Transponder Satellites
  - Digital Satellites (Packet, BPSK, PSK31, DSTAR, etc..)
  - Telemetry Only Satellites

> 105 amateur payloads have successfully operated in space

Project OSCAR

A group of Hams on the West Coast, began toying with the idea of launching an Amateur Radio satellite into orbit

- Project OSCAR formed in 1960
- Developed first contacts and relationships with the USAF
- Developed and Launched OSCAR I through OSCAR IV

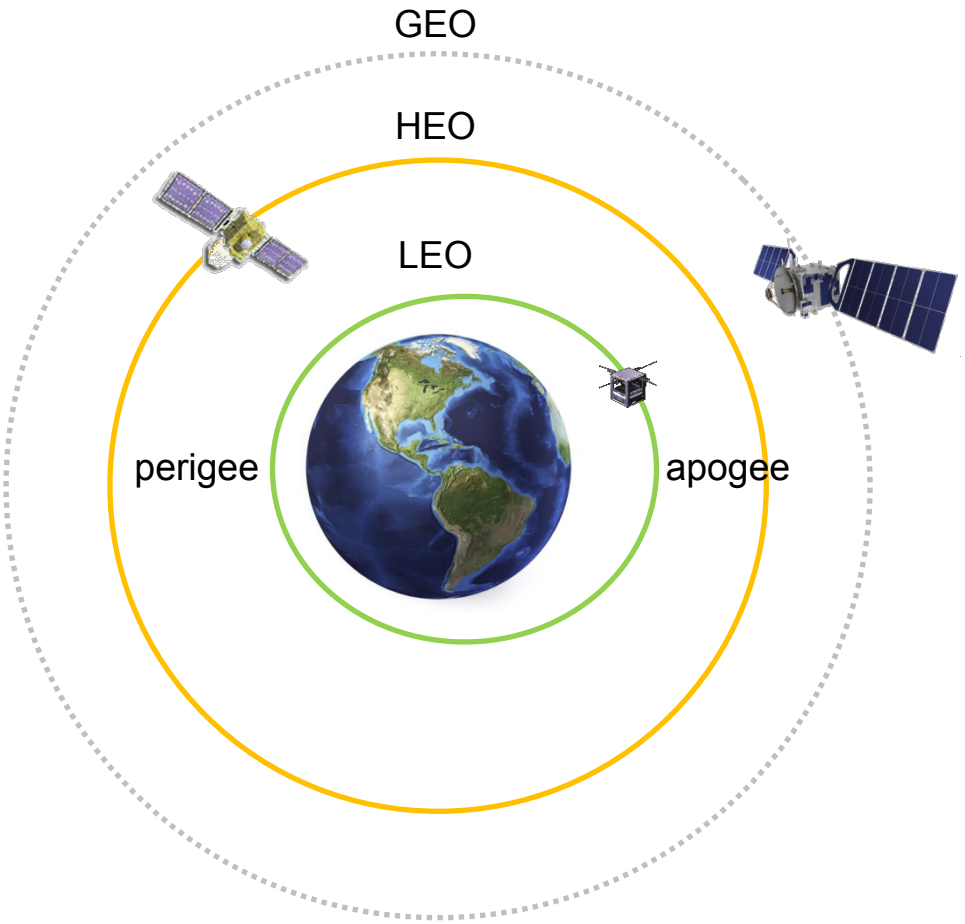
Lance Ginner, K6GSJ, builds OSCAR I in his basement workshop

Lance posing with the flight model of Amateur Radio's first satellite, OSCAR I.

Orbiting Satellite Carrying Amateur Radio

Orbits

- LEO
  - **L**ow **E**arth **O**rbit
  - 400-2,000km
  - 1.6 hours per orbit
- HEO
  - **H**igh **E**arth **O**rbit
  - > 20,000km
  - 12-14 hours per orbit
- GEO
  - **Geo**synchronous orbit
  - 35,680km



What's Up with Amateur Radio Payloads?

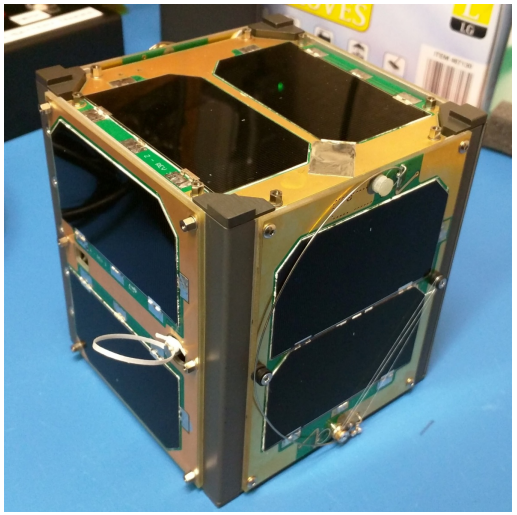
- **Analog & Digital Satellites**

✓ OSCAR 1 launched December1961
(22.0 lb 6in × 10in × 13in)

✓ AO-85 Fox-1 launched October 2015
1U CubeSat 4 × 4 × 4 and less than. 3 lbs

✓ Lunar-OSCAR 94 Launched May 2018

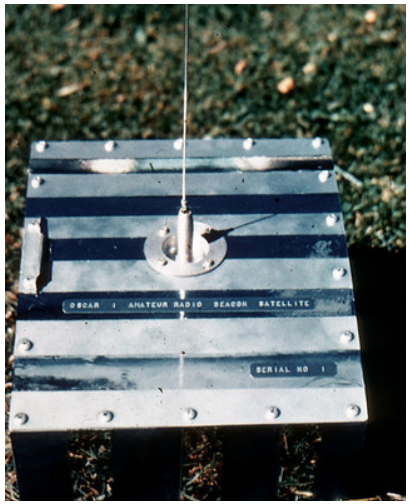
✓ QO-100 Launched November 2018
The first geostationary amateur transponder (P4-A)



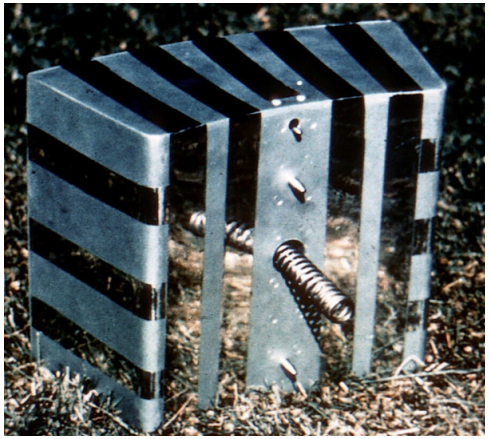
Fox-1 CubeSat

- **Manned Spacecraft**

✓ ISS crew members make random, unscheduled voice contacts

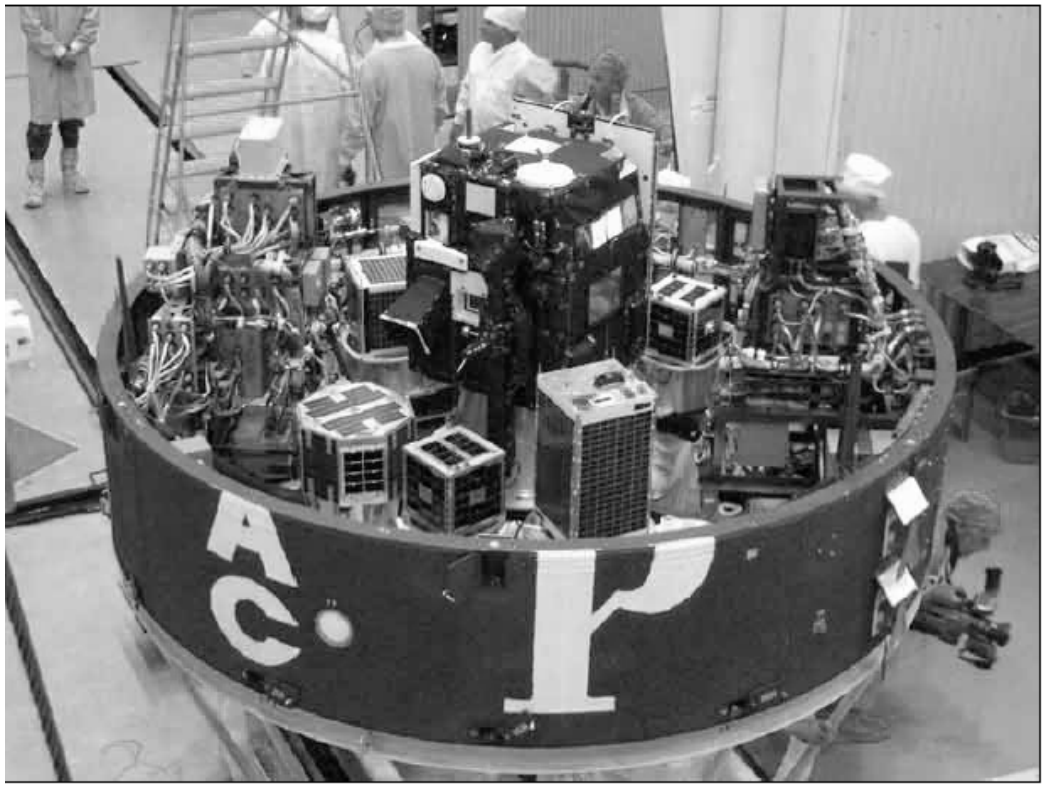


OSCAR-1



58 Years of "Orbiting Satellite Carrying Amateur Radio."

How did they get there?

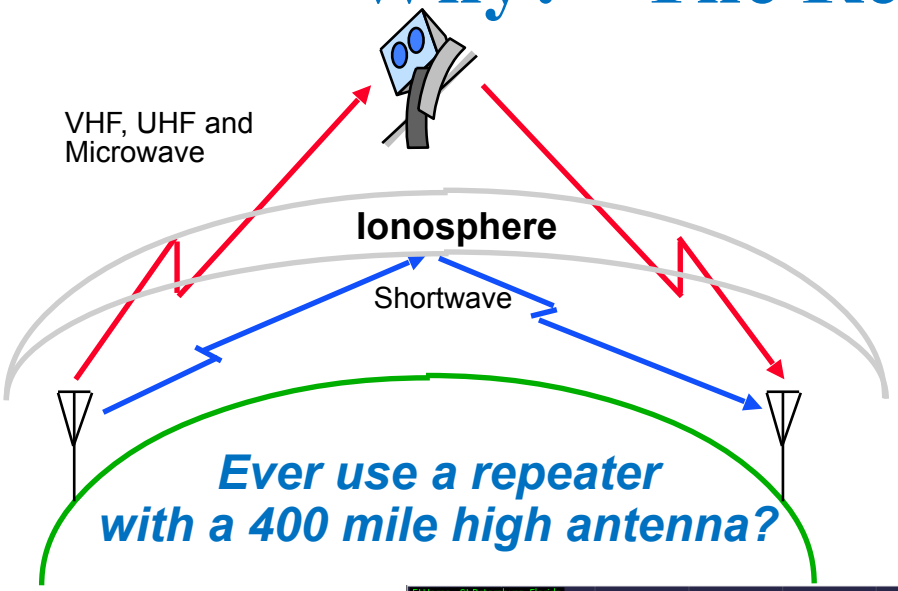


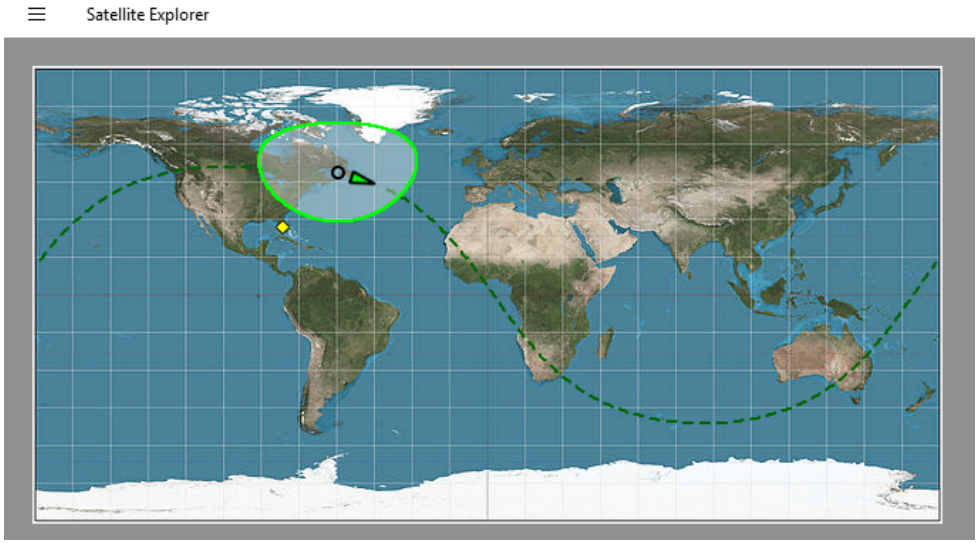
AO-51 “Space Head Module”

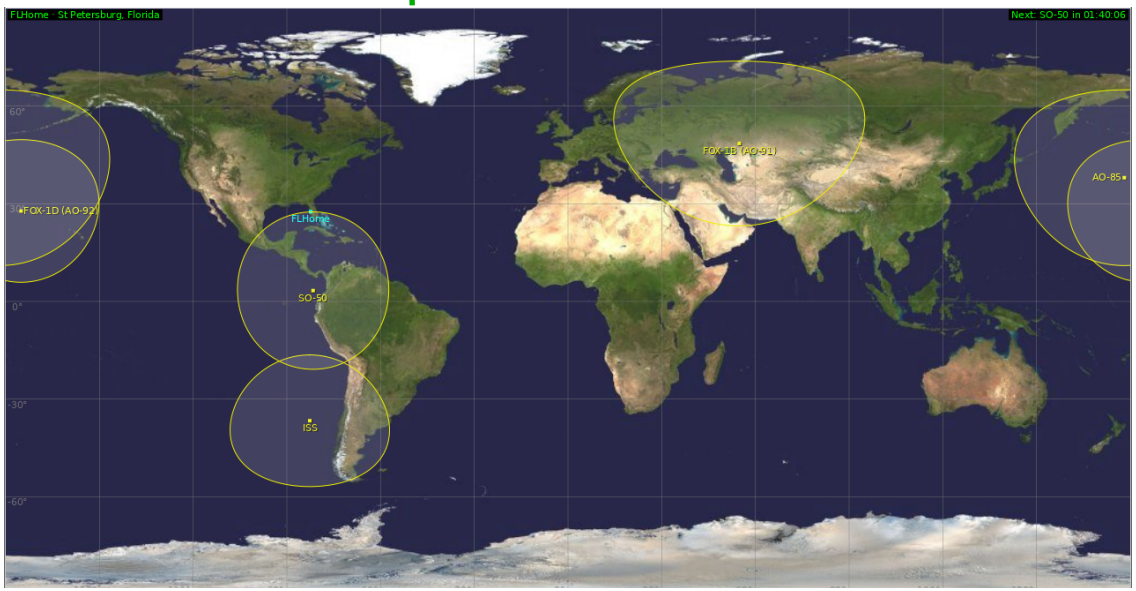
A Nasty Launch Environment

“Ballast” to survive Shock, Vibe, Radiation & Separation

Why? - The Repeater in the Sky

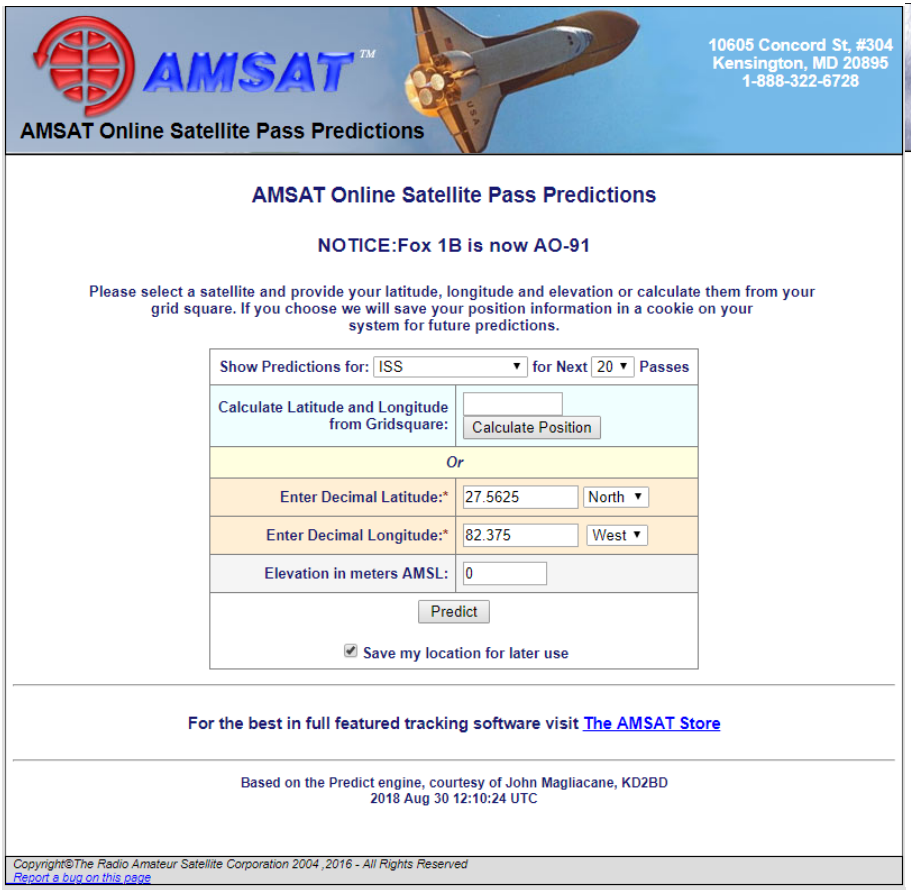






Nice view from up here!!!

When & Where are they “Visible?



AMSAT™

AMSAT Online Satellite Pass Predictions

10605 Concord St, #304
Kensington, MD 20895
1-888-322-6728

AMSAT Online Satellite Pass Predictions

NOTICE:Fox 1B is now AO-91

Please select a satellite and provide your latitude, longitude and elevation or calculate them from your grid square. If you choose we will save your position information in a cookie on your system for future predictions.

Show Predictions for: ISS ▾ for Next 20 ▾ Passes	
Calculate Latitude and Longitude from Gridsquare:	Calculate Position
Or	
Enter Decimal Latitude:*	27.5625 North ▾
Enter Decimal Longitude:*	82.375 West ▾
Elevation in meters AMSL:	0
Predict	
Save my location for later use	

For the best in full featured tracking software visit The AMSAT Store

Based on the Predict engine, courtesy of John Magliacane, KD2BD
2018 Aug 30 12:10:24 UTC

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AMSAT Online Satellite Pass Predictions - ISS

View the current location of ISS

Date (UTC)	AOS (UTC)	Duration	AOS Azimuth	Maximum Elevation	Max El Azimuth	LOS Azimuth	LOS (UTC)
30 Aug 18	16:36:05	00:09:25	336	15	37	102	16:45:30
30 Aug 18	18:12:13	00:10:14	306	30	214	157	18:22:27
31 Aug 18	07:35:08	00:08:51	182	12	121	68	07:43:59
31 Aug 18	09:10:35	00:10:23	239	33	333	33	09:20:58
31 Aug 18	10:50:17	00:05:31	300	3	326	3	10:55:48
31 Aug 18	15:44:34	00:08:05	345	8	26	84	15:52:39
31 Aug 18	17:20:06	00:10:44	316	81	228	140	17:30:50
31 Aug 18	18:58:43	00:05:15	268	3	242	208	19:03:58
01 Sep 18	06:44:39	00:06:13	158	4	133	86	06:50:52
01 Sep 18	08:18:25	00:10:40	223	84	310	42	08:29:05
01 Sep 18	09:56:48	00:07:43	280	7	321	14	10:04:31
01 Sep 18	14:53:14	00:05:48	355	3	21	62	14:59:02
01 Sep 18	16:28:11	00:10:27	325	38	60	124	16:38:38
01 Sep 18	18:05:22	00:08:24	289	10	229	183	18:13:46
02 Sep 18	07:26:36	00:10:24	206	36	112	51	07:37:00
02 Sep 18	09:03:47	00:09:12	262	13	322	22	09:12:59
02 Sep 18	15:36:24	00:09:47	333	19	33	108	15:46:11
02 Sep 18	17:12:46	00:09:54	302	22	244	164	17:22:40
03 Sep 18	06:35:10	00:09:28	189	16	129	63	06:44:38
03 Sep 18	08:11:07	00:10:09	245	24	301	30	08:21:16

Your results are shown above

Use the form below to request more pass predictions

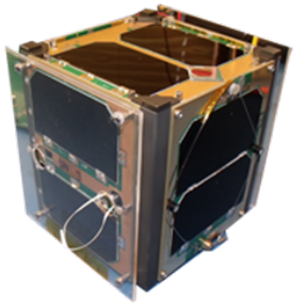
Show Predictions for: ISS ▾ for Next 10 ▾ Passes

http://www.amsat.org/

Working the FM “EasySats”

Fox-1B

AO-91



Fox-1A
AO-85

SaudiSat
SO-50

Fox-1D
AO-92

FM Satellites are repeaters, and considered “easy” to use

- Easy to hear
- Easy to work
- Easy to aim your antenna
- Easy on the Credit Card

FM Repeaters versus Transponders

Terrestrial Repeater

- Stationary
- Heavy, Bolted in Place
- Commercial Power Mains
- Single Band with duplexers
- High Power Transmitter
- Controlled Environment

- Local (LOS) Coverage

Satellite Transponder

- Flying
- Doing the Tumble
- Batteries & Solar Panels
- Cross Band
- Low Power Transmitter
- Harsh Environment of Space

- Continental /Global Coverage

Polarization & Doppler Effect are unique to SATCOM

What Does it Sound Like?

- **Full Duplex operation -- “I can hear myself!”**

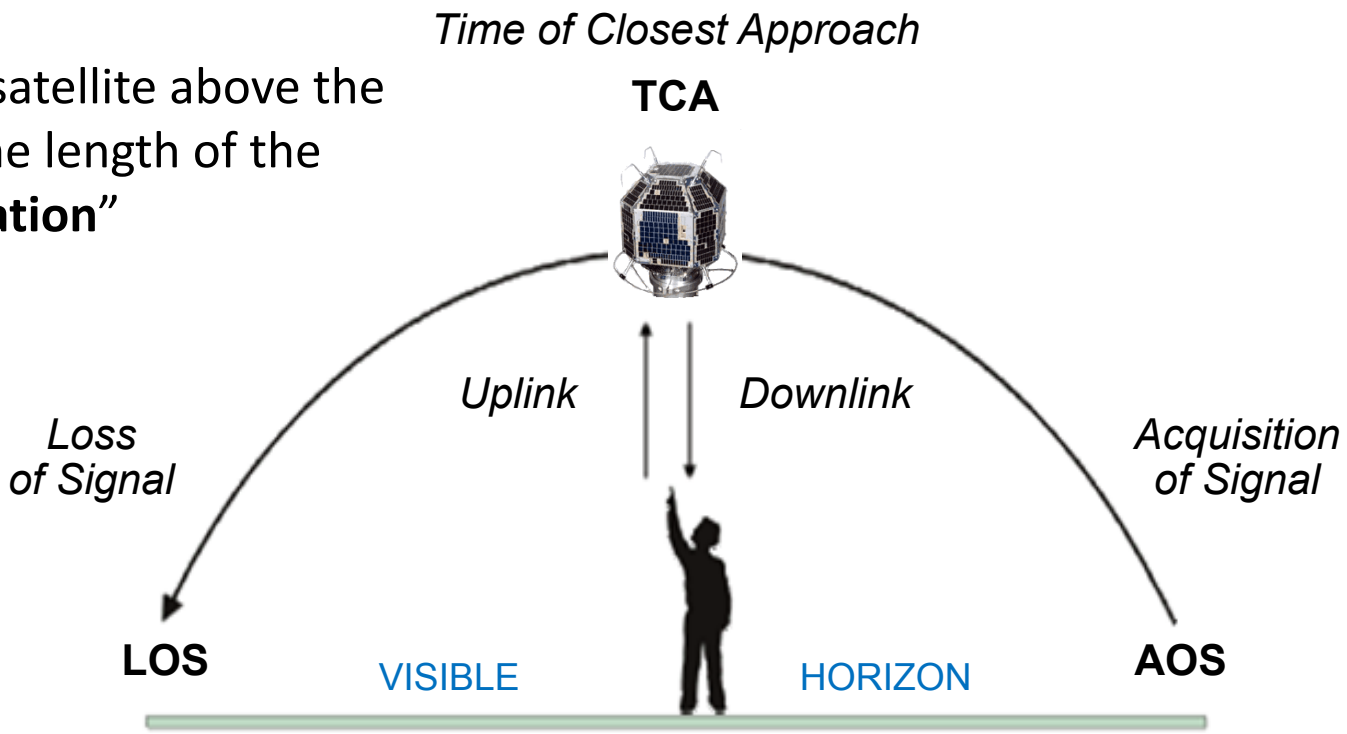
- **Short Operating Times**
  - Minimum exchange of Callsign & Grid Square
  - No Alligators-- Loud signals are discouraged.
  - The best of the courteous and skilled operators

- **A Unique Place in the Logbook of the World**
  - VUCC, WAS, DXCC, etc…
  - IOTA, SOTA, etc…

NOT Just another ham band!

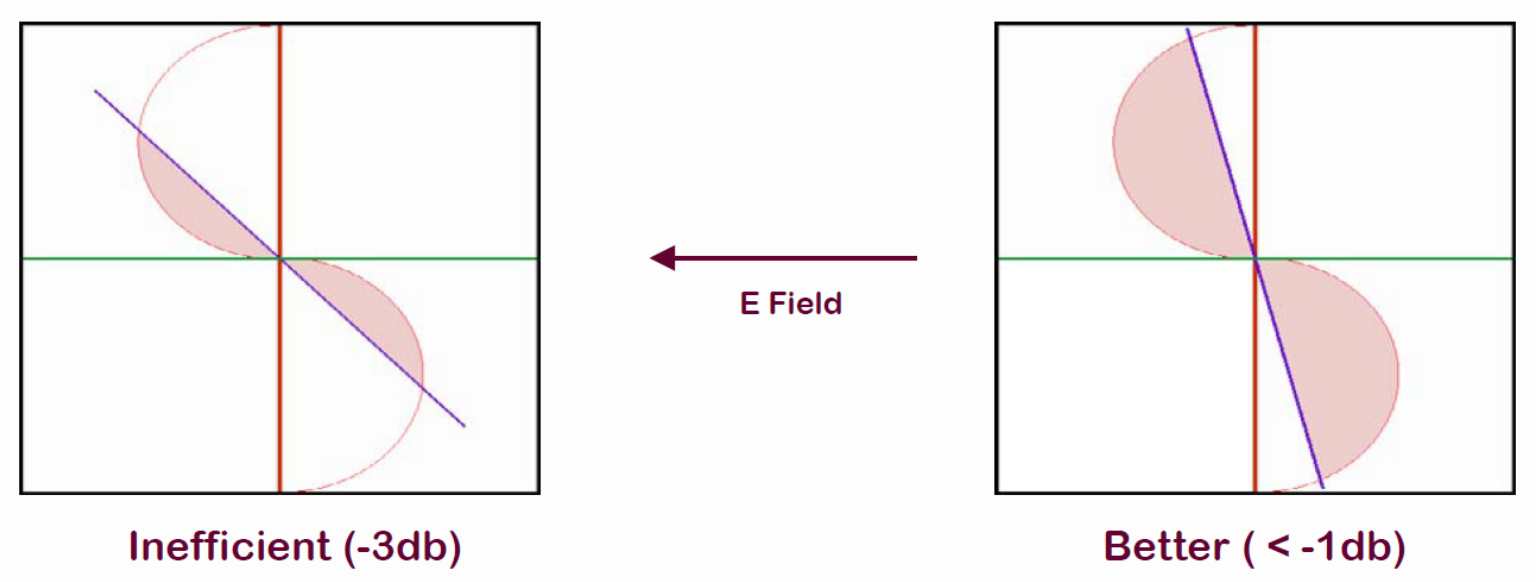
The Pass

- The time a satellite is visible (in range) to a ground station is called a satellite "**pass**."
- During a pass, you are in a "**footprint**"
- The altitude of the satellite above the Earth determines the length of the pass or "**time on station**"



Antenna Polarization

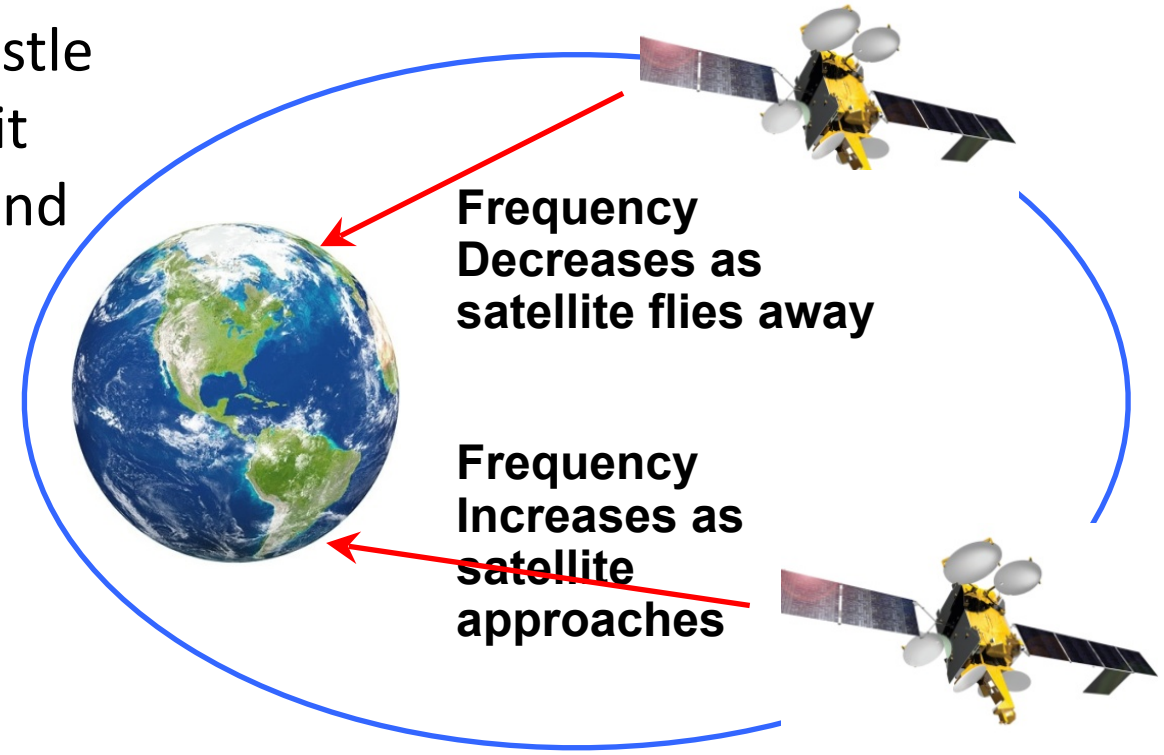
The better the match, the more of the wave you catch (and the stronger the signal)



A linear mismatch will result in a loss from 0db to -20db (at 90deg)

Doppler Effect

- The Doppler effect is an apparent change in frequency of the radio signal due to the increasing or decreasing distance between the ground station and the satellite.
- Example is a train whistle increasing in pitch as it comes towards you, and decreasing in pitch as it passes.



How do I get on the FM birds?

- **Predict the orbit** to know when and where the satellite will be passing over your location?
- Three things you need to do for success with the FM satellites are:
  - **Open up your squelch**; FM satellites do not transmit with much power – usually less than 1 Watt from 90 miles away.
  - **Antenna, antenna, antenna**; a directional antenna, dual-band Yagi or J–pole would be an improvement over whips and rubber duckies.
  - **Tune for the Doppler effect**; Start listening 10 kHz above the center frequency - you will hear the satellite sooner and clearer. When the downlink gets scratchy or fuzzy, tune down in 5 kHz steps and reception should improve.
- Make sure you can hear the satellite BEFORE transmitting.
  - It is not necessary to call CQ.
  - When you hear others, try to find a break in the action
  - Announce your **call sign and grid locator**
  - Many use headphones - especially if working full duplex.

The FM voice mode is workable with dualband HTs!

So, How Many Hands Does it Take?

- There's a lot of stuff that has to happen all at the same time
  - Tracking the satellite with your antenna
  - Twisting antenna for strongest signal (polarization)
  - Tuning Frequency changes for doppler
  - Listening for call signs/ locations
  - Transmitting PTT
  - Operating Talk,…Listen,… Talk,…Listen
  - Logging or Remembering who you talked to

Don't Panic! Breathe! You got this!

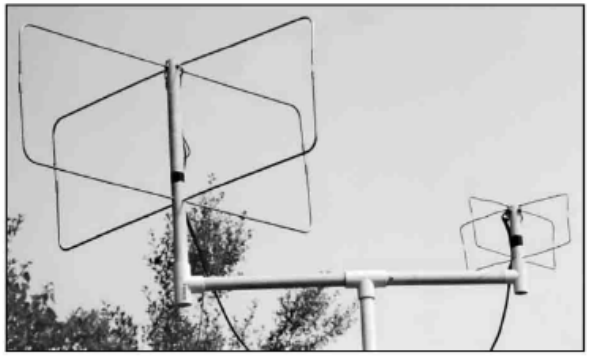
Let's Make it Easier

Simple Fixed Antennas & LNA

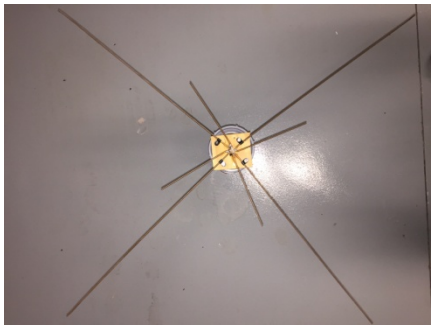
- Tracking; Omni-directional
- Twisting; Circular Polarity
- Tuning; Memory/ UHF only
- Listening; Practice
- Transmitting; PTT
- Operating; Callsign & Grid Square
- Logging; Audio Recorder

LNA's required to replace antenna gain (Gt) and mitigate cable losses.

Quadrifilar Helices at Field Day



Cebik's Crossed Moxons [1]

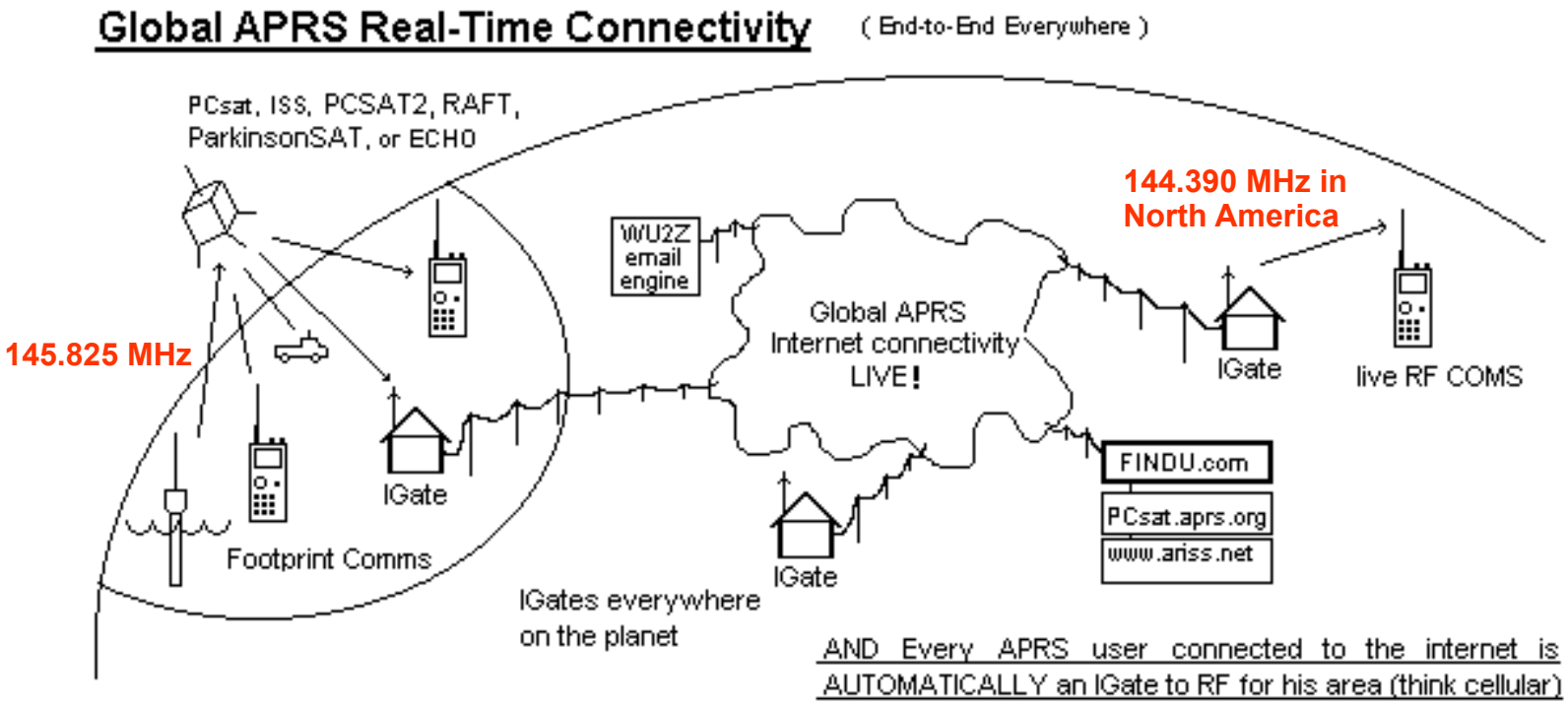


Simple Dual-band Turnstile

VUCC via Satellite is a Snap!

Ref: L.B. Cebik, W4RNL, "A Simple Fixed Antenna for VHF/UHF Satellite Work" QST Aug 2001

The APRS Network

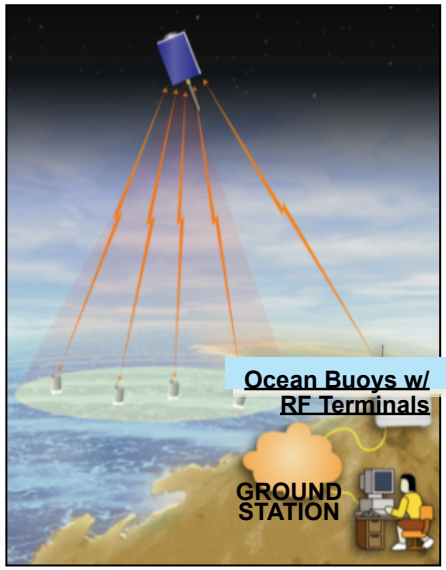


Automatic Packet Reporting System

Ref: *"Cubesat Remote Data & Comms Transponders"* Bob Bruninga WB4APR et al

Cubesat Remote Data & Comms Transponders

2015 Smallsat Cubesat Conference, Utah



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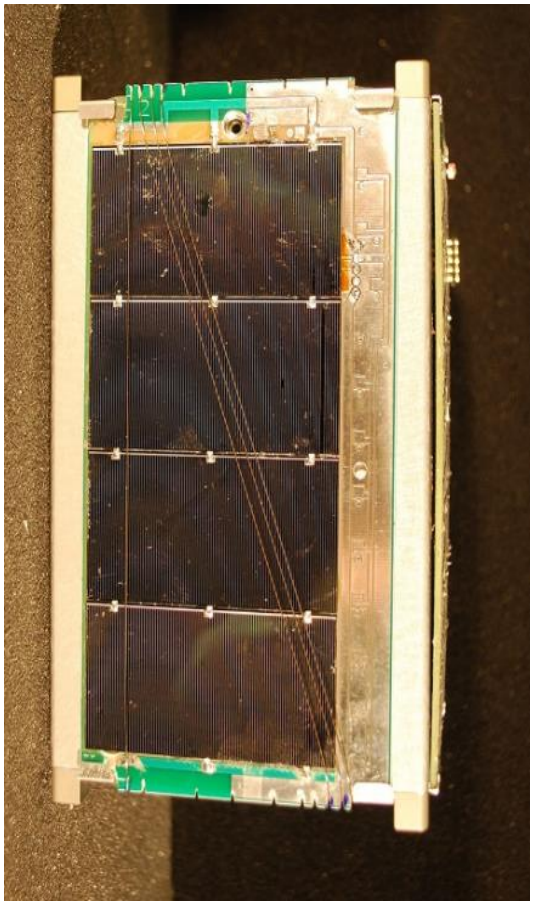
Dr. Mirek Kasal OK2AQK
Tomas Urbanec, P. Vágner

Mike Ruprecht, DK3WN



PSAT

A satellite relay channel for Amateur Satellite User data anywhere on earth.

Ground Breaking Work at the US Naval Academy

Hand-Held Satcom via APRS

"When you have *no comms*, 1200 baud text/data is great!"

CAPT Chas Richard

The "Ground Terminal" was an HT & a Palm Pilot

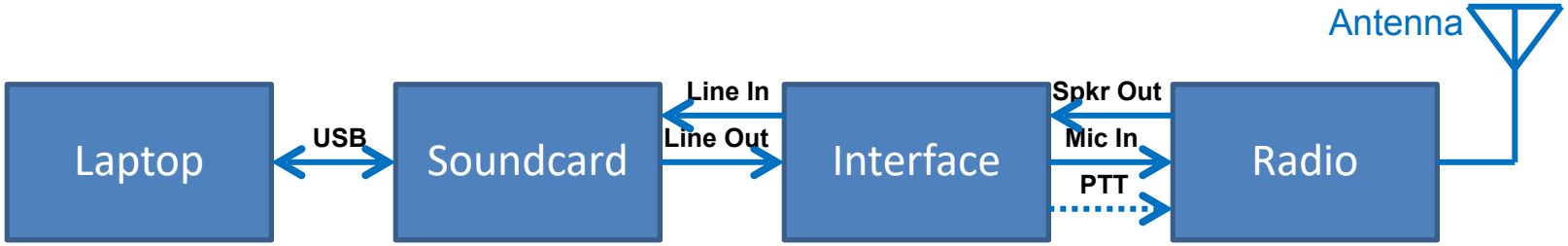
APRS & Satellite Digipeaters

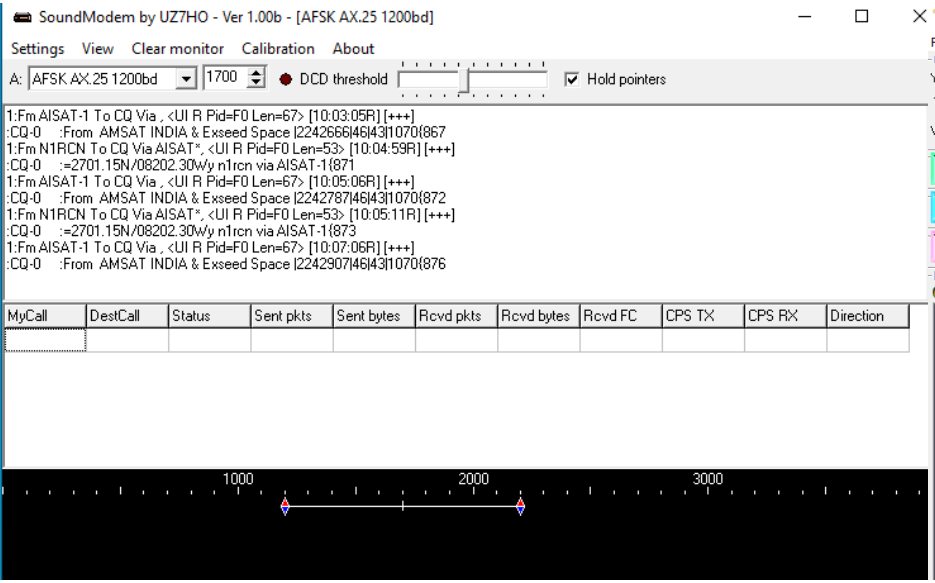
- APRS Packet communication is CONNECTIONLESS
- AX.25 UI packets eliminate handshakes
  - Maintains Error Detection
  - Defeats ACK/NACK Error Correction
- APRS is “digipeated” via satellite on 145.825 MHz
  - International Space Station (RS0ISS, alias ARISS)
  - NO-44 (PCSat, alias ARISS)
  - NO-84 (Psat-1, alias ARISS)
  - NO-104 (Psat-2, alias ARISS)
  - UiTMSat-1, BHUTAN-1, AISat-1 and more to follow
- Very compatible with terrestrial APRS messaging

APRS greatly simplifies the message exchanges

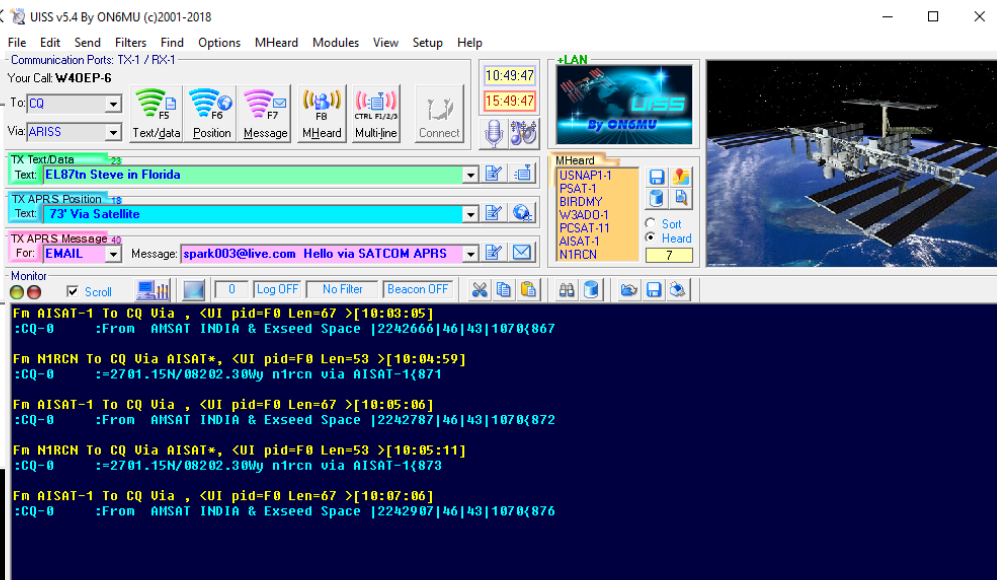
Ref: *“Add ISS Packet Operation to Your Satellite Activity,”* JoAnne Maenpaa, K9JKM

Software Modems & “Apps”





SoundModem by UZ7HO



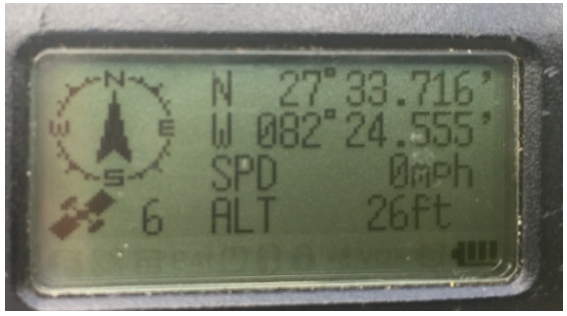
UISS bu ON6MU

Much easier than the vintage days of TNC’s

So, How Simple Can It Be?

There's **not** a lot of stuff that has to happen all at the same time

- Tracking; Omni Antenna
- Twisting; CP not needed
- Tuning; WFM mitigates doppler
- Listening; Packet Collision avoidance
- Transmitting; Automated
- Operating; Automated
- Logging; Automated



"There's an App for that!"

APRS for Safe & Well Messaging

- A minimal, "Safe & Well Messaging" Go-kit
  - Terrestrial and Satellite operations are the same
  - Simplex (144.390 & 145.825 MHz) two-meter HT
  - **Sends location, text messages and short emails**

- Demonstrated use through the International Space Station
  - A simple rollup J-pole antenna
  - iPad/iPhone, Android or similar handheld device
  - A passive interconnect box
  - A variety of Apps exist; i.e. PulseModemA, PocketPacket, MyAPRS
  - Battery powered and unattended
  - No tracking is needed but is readily available, i.e. SatSat, pxSat
  - Add a GPS Receiver or enter Lat/Lon manually

My daughter calls it her "Zombie Apocalypse" Bug-out kit

AMSAT and EmComms

- "Clearly **we cannot make a good business case** by proposing the addition of a satellite link, staffed and controlled by amateur radio 'outsiders', in many local communications scenarios."
- "Our multi-channel, multi-mode (voice, digital, video) **capability needs to be introduced to the UC/ICS community**... and (2) gain acceptance by the responder community as a viable communications solution."
- "AMSAT should **be able to speak the language of ICS** management to demonstrate how our capacity fits into emergency communications scenarios."
- "...allowing for a **portable satellite radio system to be easily and quickly deployed to disaster areas**."

Can we bring AMSAT into the Emcomm Scenarios?

Ref: *"AMSAT Opportunities for Communications Interoperability,"*JoAnne Maenpaa, K9JKM

References/Bibliography

1. "*Add ISS Packet Operation to Your Satellite Activity*" by JoAnne Maenpaa, K9JKM, January 27, 2017
2. "*AMSAT Opportunities for Communications Interoperability*," by JoAnne Maenpaa, K9JKM, AMSAT Symposium 2008
3. "*Cubesat Remote Data & Comms Transponders*" by Bob Bruninga WB4APR, Dr. Mirek Kasal OK2AQK, Mike Ruprecht, DK3WN 2015 Smallsat Cubesat Conference, Utah
4. "*APRS via ISS – Tips for successful operation*" by Silvio, DM9KS, 14OCT2017 https://www.hamspirit.net/37/aprs-via-iss-tips-for-successful-operation/
5. "*APRS Turns 35. What's Next?" by* Ray Rischpater, KF6GPE, BayCon, 9 February 2019
6. "A Simple Fixed Antenna for VHF/UHF Satellite Work" by L.B. Cebik, W4RNL, QST Aug 2001
7. *AMSAT North America*, The Radio Amateur Satellite Corporation, http://www.amsat.org/